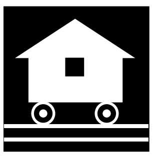
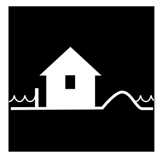
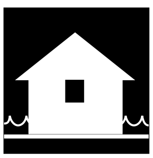
7.0 Relocation and Other Methods

7.1 Introduction

This chapter describes four alternatives to elevation (Chapter 5) and wet floodproofing (Chapter 6):


Relocation


Levees and Floodwalls

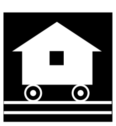

Dry Floodproofing


Demolition

These methods can be as effective as either elevation or wet floodproofing, but they are used less often because they are costly and more complex.

Keep in mind that, since each of these options is complex, you should consult design and/or construction professionals to help with your retrofit project.

7.2 Relocation



7.2.1 Introduction

Relocation – moving your home out of the flood hazard area – offers the best protection from flooding. It also can free you from anxiety about future floods and lower your flood insurance premiums. However, relocation usually is the most expensive of the retrofitting methods.

The relocation process involves lifting a home off its foundation, placing it on a heavy-duty flatbed trailer, hauling it to a new site outside the flood hazard area, and lowering it onto a new conventional foundation. The process sounds straightforward, but a number of considerations require careful planning.

7.2.2 Considerations

Condition of Home

For a home to be picked up and moved successfully, it must be structurally sound. All the structural members and their connections must be able to withstand the stresses imposed when the home is lifted and moved. Before the home is lifted, the home moving contractor must inspect it to verify its structural soundness. A home that is in poor condition, especially one that has been damaged by flooding, may need so much structural repair and bracing that relocation will not be practical (see Section 7.5 for demolition).

NOTE

Always use a licensed, bonded, and insured contractor for relocation projects. Be sure that your contractor has experience with relocation projects and understands the considerations discussed in Section 7.2.2.

For information about home relocation companies, contact the International Association of Structural Movers (IASM) at P.O. Box 2637, Lexington, SC 29071, (803) 951-9304, http://www.iasm.org/.

Home Size, Design, and Shape

In general, the types of homes that are the easiest to elevate (as discussed in Section 5.2.5) are also the easiest to relocate: single-story, wood-frame homes over a crawlspace or basement foundation, especially those with a simple rectangular shape. These homes are relatively light, and their foundation design allows the home moving contractor to install lifting equipment with relative ease. Multistory homes and solid masonry homes are more difficult to relocate because their greater size and weight requires additional lifting equipment and makes them more difficult to stabilize during the move. Slab-on-grade foundations complicate the relocation process because they make the installation of lifting equipment more difficult.

The relocation process is also more complicated for homes with brick or stone veneer, which can crack and peel off when disturbed. It may be cheaper to remove the veneer before the home is moved and replace it once the home is on the new foundation at the new site. For the same reason, chimneys may need to be removed before the move and rebuilt afterwards. If they are to be moved with the home, they must be braced extensively.

NOTE

Relocation is sometimes used as an alternative to demolition (as described in Section 7.5) when a home has been damaged. Instead of demolishing the home, the owner may be able to sell it for salvage to a contractor, who will then move the home to another site, renovate it, and sell it. Relocation can also occur after a community acquires a flood-prone property from the owner. Instead of leaving the home to be demolished, the owner may decide to keep the home and move it to property outside the flood hazard area.

Moving Route Between Old and New Sites

Restrictions along the route to the new site can complicate a relocation project, especially for large homes. Narrow roads, restrictive load capacities on roads and bridges, and low clearances under bridges and power lines can make it necessary to find an alternative route. When no practical alternatives are available, the home moving contractor may have to cut the home into sections (as shown in Figure 7-1), move them separately, and reassemble the home at the new site. Experienced home movers can make the cuts and reassemble the home in such a way that it will not appear to have ever been apart.

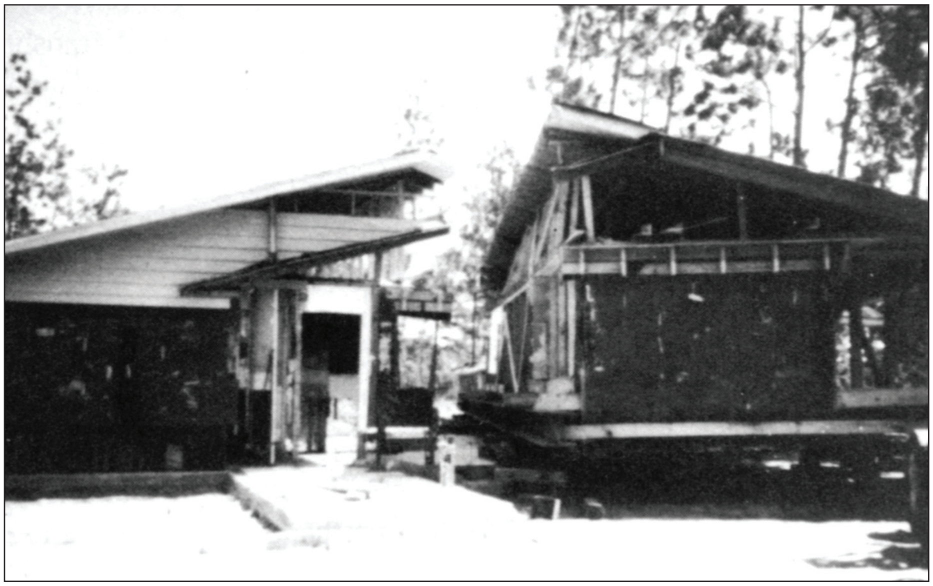


Figure 7-1. When a home is too large to be moved in one piece, it may have to be cut into sections that can be moved separately and then reassembled at the new site.

Disruption of Occupants

Among all the retrofitting methods, relocation is the most disruptive for the occupants of the home. Before the home can be lifted, all utility systems must be disconnected and the home becomes uninhabitable. You will not be able to move back in until the home has been installed at the new site and all utility systems reconnected. In the interim, you will need temporary lodgings and a place to store your furniture and other belongings.

7.2.3 The Relocation Process

The relocation process consists of more than lifting and moving the home. You must work with your contractor to select a new site for the home, and the contractor must plan the moving route, obtain the necessary permits, prepare the new site, and restore the old site.

Selecting the New Site

Selecting a new site for your relocated home is similar to selecting a site on which to build a new home. You need to consider the following:

Natural Hazards – Remember that the goal of relocating is to move your home to a site that will be

> **NOTE**
>
> See Section 4.2.3 for information about working with local officials regarding flood hazards and permitting requirements in your community.

safe from flooding and other natural hazards. Before buying new property, check with local officials about the flood, wind, and earthquake hazards at any new site you may be considering (see Section 4.2.3).

Utilities – Determine what is needed to install new utility systems and to have utility lines extended to your new site. You need to consider electrical, gas, water and sewer, telephone, and cable TV services. Your community will probably require that your new utility systems meet current code requirements. Regardless of these requirements, you should to consider upgrading one or more of your utility systems to provide more energy-efficient service.

NOTE

Regardless of the age of your home, you may be required by local regulations to bring it up to current code when you move it to a new site. This requirement could affect not only the home but also its utility systems. You should check with your local officials about such requirements before you decide to relocate.

Accessibility – Your new site must be accessible to the home movers and to the construction crews that will prepare the site and build the new foundation for your home. The more difficult it is for contractors to reach and work at your new site, the more expensive your relocation project is likely to be. If extensive grading and clearing are necessary for adequate access, some of the characteristics that made the site attractive to you may be diminished.

Another important consideration regarding accessibility is the difficulty of moving the home to the new site. In determining the best route between the old and new sites, the moving contractor must anticipate potential problems, such as narrow bridges. For example, the progress of the home may be impeded by narrow bridges and road cuts, bridges with low weight limits, low-hanging utility lines and traffic signals, low underpasses, tight turns, road signs, and fire hydrants.

The moving contractor should be responsible for coordinating any special services that may be required to deal with obstacles, such as raising traffic lights, relocating signs, and constructing temporary bridges. Utility lines can usually be raised temporarily during the move, but utility companies often charge for this service. In some cases, it may be possible to avoid some obstacles by choosing an overland (non-road) travel route.

Permitting

You or your moving contractor will have to obtain permits to move the home on public roads or other rights-of-way. These permits may be required by local governments, highway departments, and utility companies, not only in the jurisdiction from which your home is being moved, but also any jurisdiction through which the home will pass. If the moving route crosses or affects private land, you may need to obtain the approval of the landowner.

Obtaining the necessary permits and approvals may be a lengthy and complex process, and you may find that the requirements vary from jurisdiction to jurisdiction and agency to agency. So it is extremely important that you, your design professional, and your moving contractor investigate the need for permits and approvals before you make a final decision to relocate.

You or your design professional should check with local officials to make sure that, when your home is moved to the new site, it will conform to all zoning requirements and building codes in effect at the time of the relocation. The design professional should also determine the local design standards and permitting requirements that govern the development of your new site. All permits required for construction at the new site, moving your home, and restoring the old site after the home is moved should be obtained <u>before</u> the relocation project begins.

Preparing the New Site

Before the home is moved, the new foundation is designed and is usually partially constructed. The foundation will be completed after the home is brought to the site. Clearing, excavation, and grading are necessary to allow construction to begin and to ensure that the home can be maneuvered on the site. Also, unless already available, utility service must be brought into the site so that there will be no delay in connecting them to the home and making it habitable.

Lifting the Home

In general, the steps required in lifting a home off its foundation are the same as those described in Section 5.3.1 for elevating a home on extended foundation walls. As described in Section 5.3.2, the steps for homes on basement and crawlspace foundations differ from those for homes on slab-on-grade foundations.

> **NOTE**
>
> Refer to Section 5.3 for a description of how homes on various types of foundations are lifted off their foundations.

Homes on basement and crawlspace foundations are separated from their foundations and lifted on steel I-beams that pass through the foundation walls directly below the floor framing. The lifting is done with hydraulic jacks placed directly under the I-beams. The process for homes on slab-on-grade foundations is similar. However, because these homes are lifted with the concrete floor slab attached, the I-beams are inserted below the slab.

Moving the Home

After the home is lifted, the moving contractor performs whatever grading and excavation are necessary to create a temporary roadway that will allow the home to be moved to the street. The area beneath the home must be leveled and compacted so that trailer wheel sets can be placed under the home (Figure 7-2). The wheel sets and lifting beams form the trailer on which the home will be moved.

Figure 7-2. Trailer wheel sets are placed beneath the lifting beams.

After the wheels are attached, a tractor or bulldozer tows the home to the street. As the home is being moved, workers continually block the wheels to prevent sudden movement. At the street, the home is stabilized, the trailer is attached to a truck, and the move to the new site begins (Figure 7-3).

Figure 7-3. The move to the new site begins.

At the new site, the moving contractor positions the home over the partially completed foundation and supports the home on cribbing so the trailer wheels can be removed. As in the home elevation process described in Chapter 5, the home is lifted on hydraulic jacks to the desired height and the foundation is completed below it (Figure 7-4). The home is then lowered onto the foundation, all utilities are connected, and any necessary backfilling and landscaping is completed.

Figure 7-4. After the home is raised into place, the foundation is completed.

Restoring the Old Site

After the home is moved, the old site must be restored according to the requirements of local regulations. Restoring the site usually involves demolishing and removing the old foundation and any pavement, such as a driveway or patio; backfilling an old basement; removing all abandoned utility systems; grading to restore areas disturbed by demolition; and stabilizing the site with new vegetation. Permits are normally required for demolition, grading, and vegetative stabilization.

NOTE

Many homeowners have sold or deeded vacated flood-prone properties to local municipalities for use as parkland or open space.

If your old site included a septic tank or fuel storage tank, you may have to meet the requirements of environmental regulations aimed at preventing contamination of the groundwater. Depending on the age and condition of the tank, you may be required to drain and remove it. If it is an underground tank, you may have to drain and anchor it to prevent flotation. You may also be required to test the soil around an underground fuel tank to determine whether leakage has occurred. As the homeowner, you will usually be responsible for cleaning contaminated soil if there has been any leakage from the tank. In this situation, you will need the services of a qualified geotechnical or environmental engineer.

Local utility companies or regulatory officials can inform you about requirements concerning capping, abandoning, or removing various utility system components.

7.3 Dry Floodproofing

7.3.1 Introduction

Dry floodproofing involves completely sealing the exterior of a building to prevent the entry of floodwaters. Unlike wet floodproofing (Chapter 6), which allows water to enter the building through wall openings, dry floodproofing seals all openings below the flood level and relies on the walls of the building to keep water out.

Because the walls are exposed to floodwaters and the pressures they exert, dry floodproofing is practical only for homes with walls constructed of flood damage-resistant materials and only where flood depths are low (no more than 2 to 3 feet). Successful dry floodproofing involves the following:

- Sealing the exterior walls of the home
- Covering openings below the flood level
- Protecting the interior of the home from seepage
- Protecting service equipment outside the home

WARNING

Dry floodproofing cannot be used to bring a substantially improved or substantially damaged home into compliance with the requirements of your community's floodplain management ordinance or law. In addition, dry floodproofing measures can fail during larger flood events.

The following sections discuss the most important considerations regarding dry floodproofing and describe the modifications that must be made to a home as part of a dry floodproofing project. Protection of service equipment is discussed in Chapter 8.

7.3.2 Considerations

Flood Depth

The primary consideration in dry floodproofing, and the one that imposes the greatest limitations on the application of this method, is the effect of hydrostatic pressure. Because dry floodproofing prevents water from entering the home, the external hydrostatic pressure exerted by floodwaters is not countered by an equal force from water inside the home (see Chapter 2). This external pressure results in two significant

NOTE

For additional information about dry floodproofing techniques, refer to FEMA Technical Bulletin 3-93, *Non-Residential Floodproofing—Requirements and Certification* and FEMA 259, *Principles and Practices for Retrofitting Flood-Prone Residential Structures.*

problems: heavy unequalized loads on the walls of the home and buoyancy, or uplift force, which acts on the entire home.

When water rises against a wall, it pushes laterally against the wall. As the depth of water increases, so does this force, as indicated by the arrows in Figure 7-5. Tests performed by the U.S. Army Corps of Engineers (USACE)[1] have shown that, in general, the maximum allowable flood depth for masonry and masonry veneer walls is approximately 3 feet. In these tests, walls exposed to greater depths of water either collapsed or suffered serious structural damage.

Although definitive testing has not been carried out for conventional frame walls without masonry veneer, it is generally accepted that they are difficult to seal, weaker than masonry and masonry walls, and thus likely to fail at lower water depths.

Hydrostatic pressure is exerted not only by floodwater, but also by soils saturated by floodwaters. As a result, basement walls can be subjected to pressures much greater than that from 3 feet of water alone (Figure 7-6). These pressures can easily cause basement walls to buckle inward or collapse (Figure 2-8). <u>For this reason, dry floodproofing in basements is strongly discouraged. In fact, your community's floodplain management ordinance or law does not allow basements in substantially improved or substantially damaged homes to be dry floodproofed.</u>

As shown in Figure 7-6, water and saturated soils also push up from below the home. This buoyancy force causes additional problems and creates a potential for damage that underscores the need to restrict dry floodproofing to areas where flood depths are low and to prohibit dry

WARNING

The flood depth limits discussed here are provided as general guidelines only. Before you attempt to dry floodproof your home, a design professional, such as a structural engineer, must inspect it to determine whether it is structurally sound.

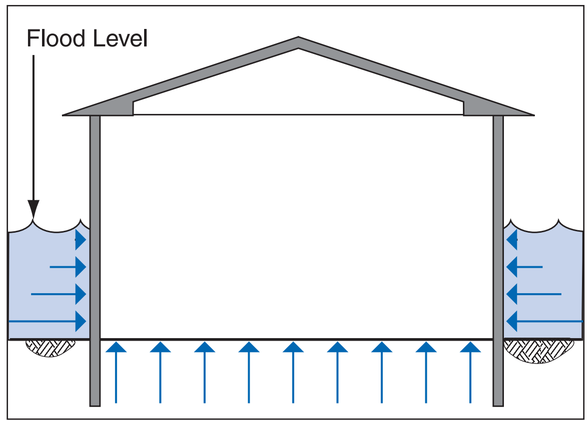


Figure 7-5. The hydrostatic pressure exerted by floodwater (including buoyancy) increases with depth.

NOTE

Always consult a licensed, bonded, and insured contractor for dry floodproofing projects. Be sure that your contractor has experience with dry floodproofing and understands the considerations discussed in Section 7.3.2.

1 The test results are documented in the following reports published by the USACE National Flood Proofing Committee: *Flood Proofing Tests – Tests of Materials and Systems for Flood Proofing Structures,* August 1988; *Systems and Materials to Prevent Floodwaters from Entering Buildings*, May 1985; *Structural Integrity of Brick-Veneer Buildings*, 1978; *Tests of Brick-Veneer Walls and Closures for Resistance to Floodwaters*, May 1978.

floodproofed basements. The buoyancy force resulting from flood depths of over 3 feet can separate a dry floodproofed home from its foundation and buckle concrete slab floors in dry floodproofed slab-on-grade homes. It may be difficult to imagine, but it is possible for a home with a dry floodproofed basement to be pushed out of the ground during large floods.

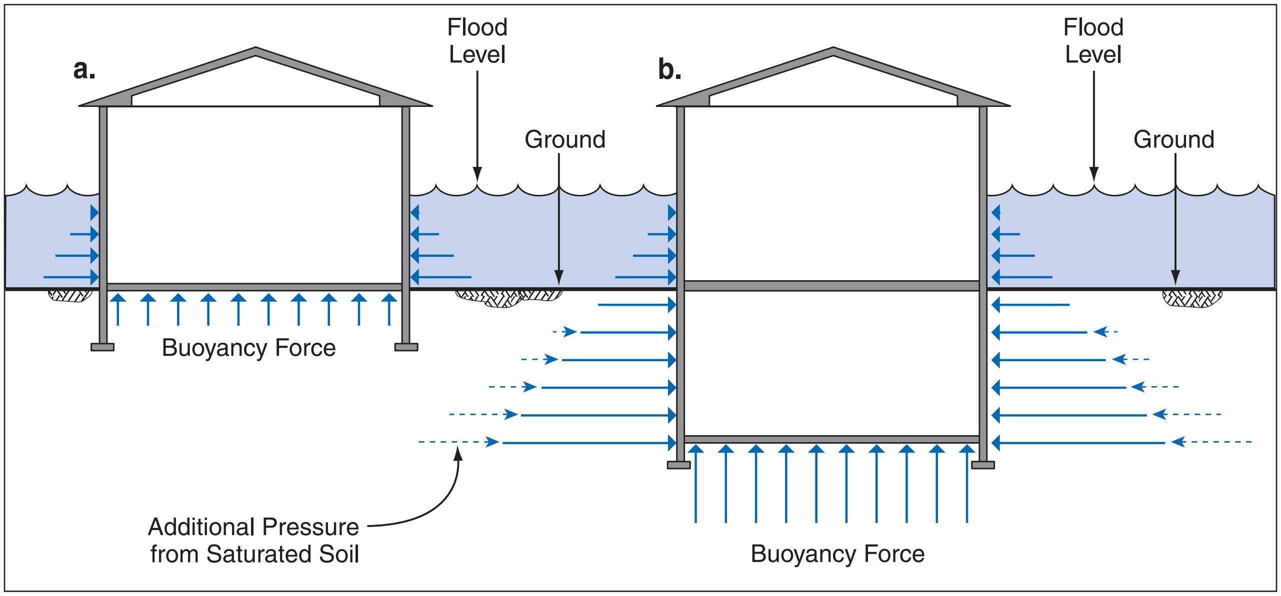


Figure 7-6. The lateral and buoyancy force resulting from the same depth of flooding is much less on a home without a basement (a) than on a home with a basement (b). The pressure on basement walls is caused by water and saturated soils.

The degree of danger posed by buoyancy depends on the flood depth, the type of soil at the home site, how saturated the soil is, the duration of the flood, whether the home has a drainage collection and disposal system, and how well that system works. Only an experienced engineer can evaluate these factors.

Flow Velocity, Erosion and Scour, Debris Impact, and Wave Action

Dry floodproofing does not protect a home from the hydrodynamic force of flowing water, erosion and scour, the impact of ice and other floodborne debris, or wave action. If your home is located in an area subject to any of these hazards, you should consider an alternative retrofitting method, such as elevation on an open foundation (Chapter 5), relocation (Section 7.2), or demolition (Section 7.5). Dry floodproofing a home does not change its vulnerability to damage from high winds or earthquakes.

Flood Duration

Flood duration is an important consideration because the potential for seepage through and deterioration of the materials used to seal the home increase with the length of time that the home is exposed to flooding. Also, the longer the duration, the greater the likelihood that the soil beneath and adjacent to the home will become fully saturated and add to the loads on the walls and floor (Figure 7-6). If your home is in an area where floodwaters remain high for days, weeks, or even months at a time, you should consider an alternative retrofitting method, such as elevation or relocation.

Human Intervention

Dry floodproofing systems almost always include components that have to be installed or activated each time flooding threatens. One example is a flood shield placed across a doorway. For this reason, dry floodproofing is not an appropriate retrofitting method in areas where there is little or no flood warning or where, for any other reason, the homeowner will not be able or willing to install shields or other components before floodwaters arrive.

Post-Flood Cleanup

Remember that floodwaters are rarely clean. They usually carry sediment, debris, and even corrosive or hazardous materials such as solvents, oil, sewage, pesticides, fertilizers, and other chemicals. The walls of a dry floodproofed home will be exposed to whatever is in the floodwaters. Cleaning up a dry floodproofed home after a flood may, therefore, involve not only removing mud and debris from around the home, but also decontaminating or disinfecting walls and other exterior surfaces.

7.3.3 Modifications Required for Dry Floodproofing

Dry floodproofing involves the use of sealants and shields, installation of a drainage system, and protection of service equipment.

Sealants

Except for some types of high-quality concrete, most wall materials are not impervious to water. Therefore, sealants must be applied to the walls of a dry floodproofed home to prevent leakage. Flexible sealants are compounds (such as asphalt coatings) or materials (such as polyethylene film) that are applied directly to the outside surface of the home walls. Sealants must also be applied to all structural joints, such as the joint between the walls and a slab floor, and to any other openings below the flood level, such as those where utility lines enter the home through the walls or floor.

Sealants that can be applied to outside walls include cement- and asphalt-based coatings and clear coatings such as epoxies and polyurethanes. Cement- and asphalt-based coatings are often the most effective, but they can change the appearance of the wall (Figure 7-7). For example, the aesthetic advantage of a brick wall is lost when these coatings are applied over the brick. Clear coatings do not change the appearance of the wall, but are less effective.

Figure 7-8, a cross-section view of an exterior wall, shows one method of sealing masonry walls with an asphalt-based coating that does not detract from their appearance. In this method, a new masonry veneer is added to the existing veneer after the coating is applied. In addition to maintaining the look of the wall, the new veneer helps protect the wall against damage from floodborne debris.

Figure 7-7. A 12-inch high asphalt coating was added to this brick wall.

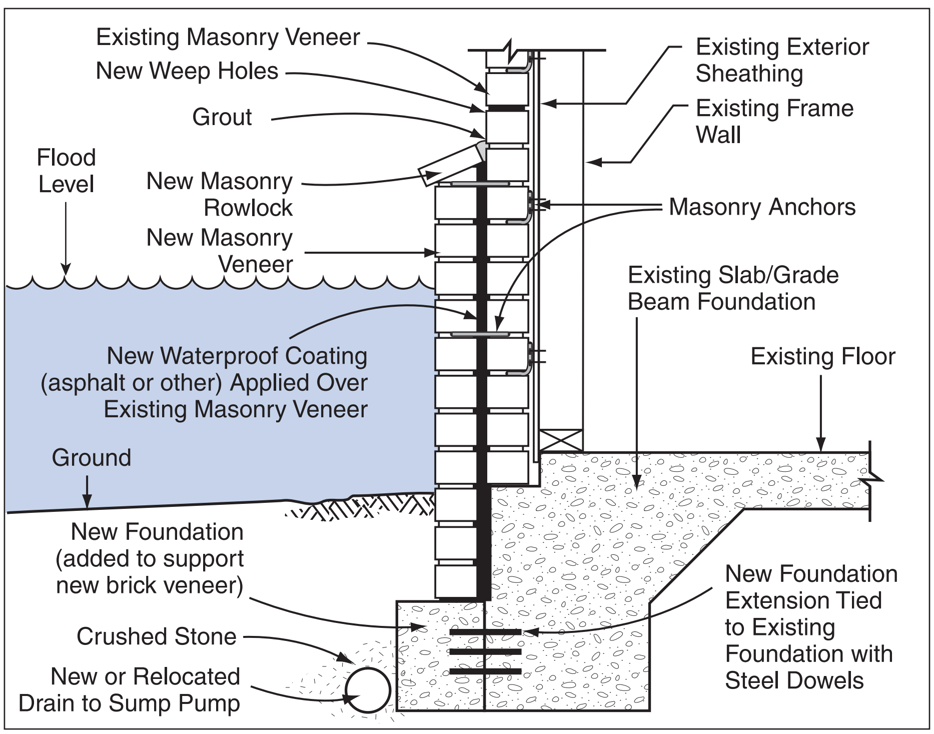


Figure 7-8. New brick veneer added over asphalt coating.

An alternative to using coatings is to temporarily wrap the entire lower part of the home in polyethylene film when flood conditions threaten. This alternative is sometimes referred to as the "wrapped home" technique. The cross-section view in Figure 7-9 shows how this technique works. There must be at least several hours of warning time in order to properly deploy this method.

Polyethylene film is not a strong material – it cannot withstand water pressure on its own and can be punctured fairly easily. As a result, the following requirements must be met when the wrapped home technique is used:

- The installation must be carried out very carefully. Even a small hole in the film will leak under the pressure of floodwaters.
- The film must be applied directly against the walls of the home so that the walls, rather than the film, provide the resistance to water pressures.
- Where the film covers doorways and other openings, it must be backed by framed plywood panels that are braced to resist water pressures.
- A temporary drainage system must be provided to collect and dispose of any water that leaks through holes in the film. (Drainage systems are discussed later in this section.)
- The duration of flooding should be less than 12 hours and the flood depth adjacent to the home should not exceed 1 foot.

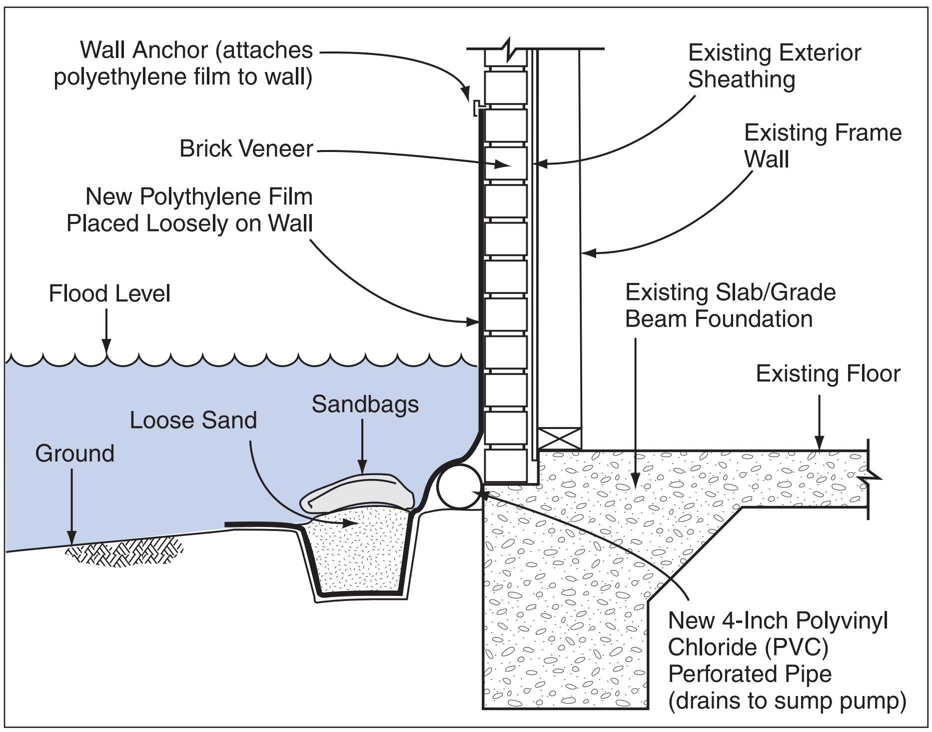


Figure 7-9. In the "wrapped home" method, the lower portion of the home is protected with a temporary layer of polyethylene film. As shown, a temporary drainage line is also required.

Because the wrapped home technique is only temporary, it does not change the normal appearance of your home. However, like any temporary technique, it requires extensive human intervention. All the necessary materials must be immediately available, and it will usually take four to six people several hours to put them into place. Therefore, you must have adequate warning every time flooding threatens so that you can install both the film and drainage system.

Commercial versions of the wrapped home technique are available. Usually, they consist of a system of vinyl-coated nylon wrapping mounted on rollers, which are contained in boxes permanently installed in the ground around the perimeter of the home. To protect the home, you open the boxes, pull the material out, and attach it to hooks or clips mounted on the walls of the home. The primary advantages of these commercial systems are that they provide a stronger barrier and allow for a shorter installation time. However, commercial home wrapping systems do not, by themselves, strengthen the walls of a home; if depths greater than 3 feet are expected, the walls must be adequately reinforced. Also, these systems do not eliminate the need for adequate drainage lines and sump pumps.

Shields

Shields are flood barriers placed over openings in walls such as doorways and windows. Shields can be made of any of several materials, depending on the size of the opening to be covered, and should include a gasket along the edge of the shield. When flood depths are expected to reach the maximum allowable 2 to 3 feet, shields for openings wider than approximately 3 feet must be made of strong materials such as heavy-gauge aluminum or steel plate (Figure 7-10); shields for lesser depths and smaller openings can be made of lighter materials.

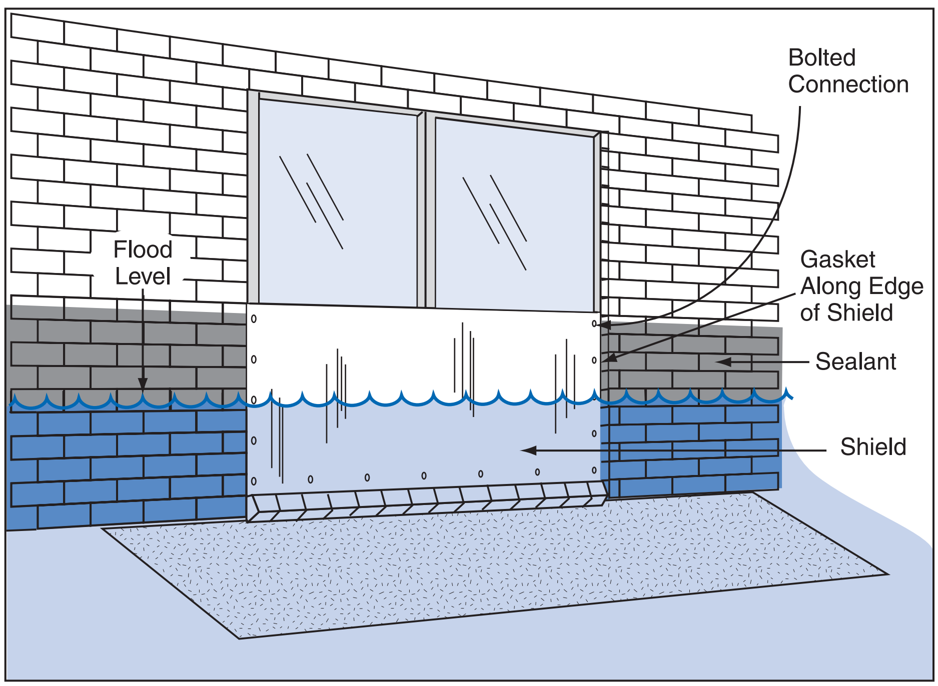


Figure 7-10. Heavy-gauge metal shield over sliding glass door opening.

Because permanently blocking all doors and other openings would be impractical, shields are usually placed temporarily, after flood warnings are issued. Smaller, lighter shields can be stored in the home and, when needed, brought out and bolted in place or secured in permanently installed brackets or tracks (Figure 7-11). Larger, heavier shields may have to be permanently installed on hinges or rollers so that they can be opened and closed easily.

Companies that specialize in flood protection devices can provide custom-fitted flood shields. Usually, these commercial shields are made of heavy-duty materials, and some are equipped with inflatable or other types of gaskets that help prevent leaks.

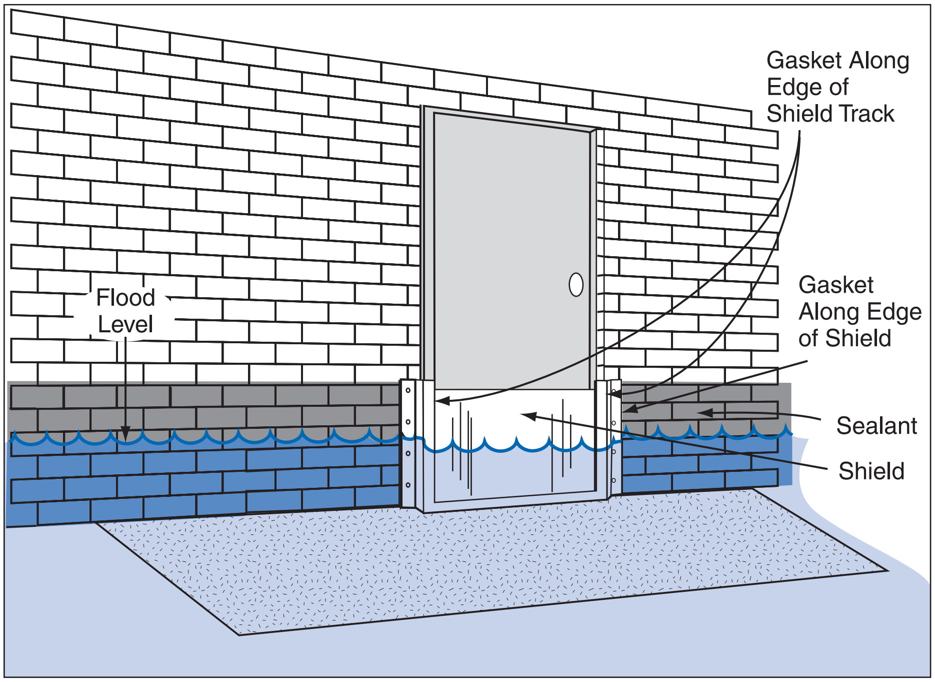


Figure 7-11. Light-gauge metal shield held in place by permanently installed tracks.

An alternative to using shields is to permanently seal openings. For example, a low-level window can be removed or raised and the opening bricked up or filled with glass block (Figure 7-12).

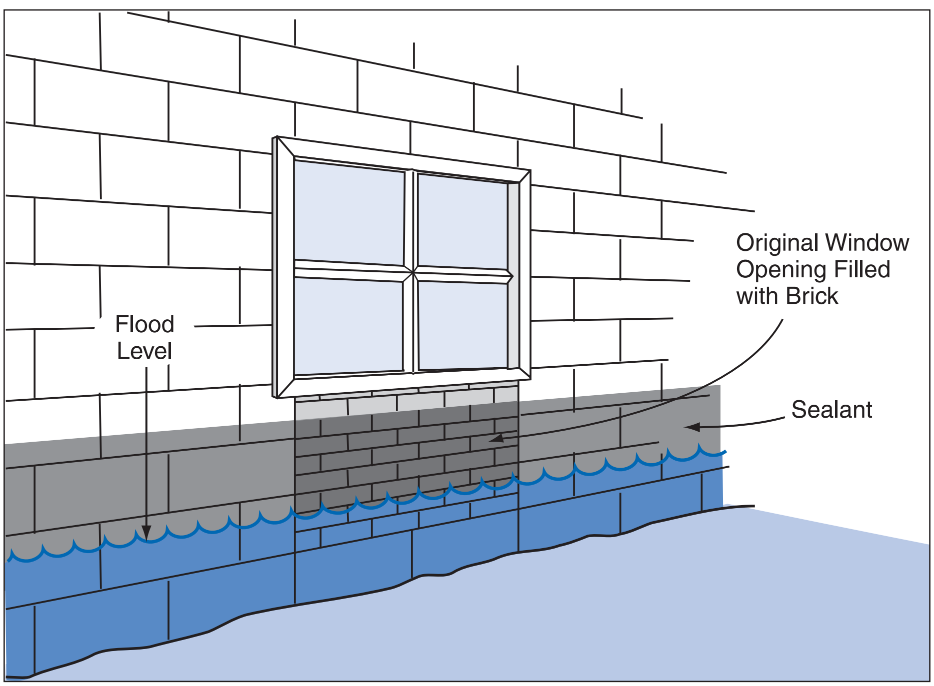


Figure 7-12. Low window raised approximately 2 feet and original opening filled with brick.

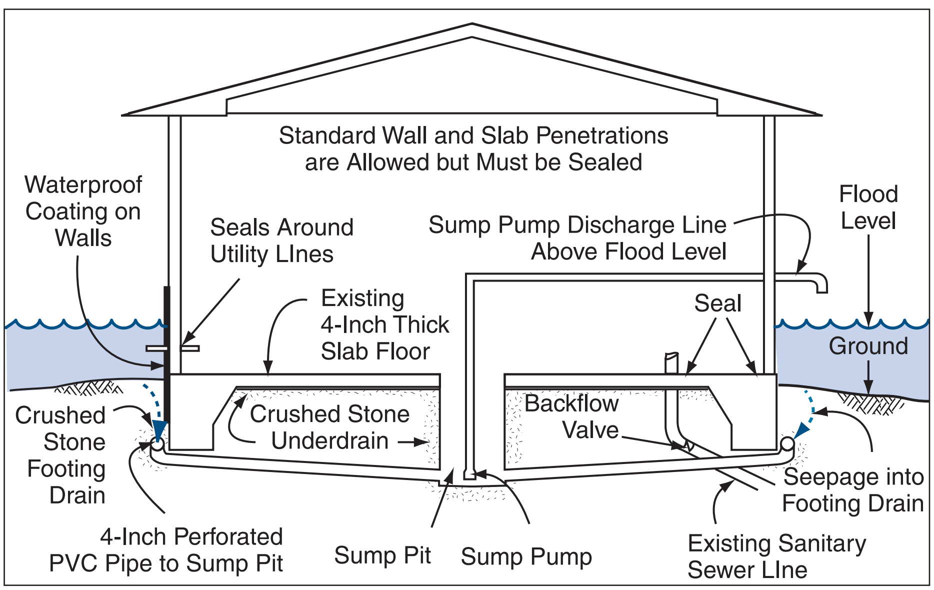
Drainage Systems

Sealants and shields provide the bulk of the protection in dry floodproofing, but they may permit some leakage, especially during floods of longer duration and when damaged by debris. They also do not protect against "**underseepage**" – water that migrates downward along the sealed wall and then under the foundation. For these reasons, a dry floodproofed home must have a drainage system that will remove any water that enters the home through leaks in sealants and shields and any water that accumulates at the base of the foundation. Depending on the permeability of the soils around and under the home, the drainage system may also have to be designed to reduce buoyancy forces.

> **DEFINITION**
>
> **Underseepage** refers to water that migrates downward along the sealed walls of a home and then under the foundation.

An adequate drainage system includes drains along the base of the foundation and under the floor. The drains consist of perforated pipe surrounded by crushed stone. The pipes collect water that seeps through the ground and channel it to a central collection point equipped with a sump pump. This system is shown in Figure 7-13. The sump pump must have sufficient capacity to handle the inflow of water and must have an emergency power source, such as a portable generator, so that it will continue to operate if conventional electric service is disrupted.

Figure 7-13. Drainage system for a dry floodproofed home.



Protecting Service Equipment

Dry floodproofing a home will not protect service equipment outside the home. Examples of service equipment normally found outside the home are utility lines, air conditioning compressors, heat pumps, and fuel storage tanks. Chapter 8 discusses the protection of service equipment.

7.4 Levees and Floodwalls

7.4.1 Introduction

Levees and floodwalls are both barriers that hold back floodwaters, but they differ in their design and construction, appearance, and application. Levees are embankments of compacted soil. They usually have rounded outlines and can be blended into the natural landscape of the home site. Floodwalls are structures built of manmade materials, such as concrete and masonry. Although they cannot be made to look like a natural landscape feature, they can be designed and constructed in such a way that they complement the appearance of the home and its site.

WARNING

Levees and floodwalls cannot be used to bring a substantially improved or substantially damaged home into compliance with the requirements of your community's floodplain management ordinance or law.

A levee requires more land area than a floodwall of comparable height; therefore, for small lots levees are less practical than floodwalls. Floodwalls, because of their design, construction, and more efficient use of space, not only can be built on smaller lots but also can be used selectively in conjunction with other retrofitting methods. For example, you can build a small exterior floodwall to protect an individual window or door in the wall of a dry floodproofed home. You can protect a walkout-on-grade basement by building a floodwall that ties into the ground where the grade rises above the flood elevation on the sides of the home. This approach is illustrated in Table 3-14, in the sample cost estimate for levees and floodwalls. You can also build an interior floodwall to protect service equipment in the basement of a wet floodproofed home (see Chapter 8).

NOTE

Always use a licensed, bonded, and insured contractor for levee and floodwall projects. Ensure that your contractor has experience designing and constructing levees and floodwalls and understands the considerations discussed in Section 7.4.2.

There are currently thousands of miles of levees across the country that affect millions of people, and it is important to understand the risks associated with living behind levees. Levees and floodwalls are designed to provide a specific level of protection, and larger flood events can cause them to be overtopped. Levees and floodwalls require regular maintenance and periodic upgrades to ensure that they retain their level of protection and continue to perform as intended.

If you decide to build a levee or floodwall on your property, you must consult with your local official to make sure it is allowed under your local floodplain ordinance. You should then consult a licensed professional engineer and work with licensed contractors to ensure that the levee or floodwall meets current design, operations, and maintenance criteria. Individual residential levees or floodwalls cannot be used to bring a home with a first floor elevation below the BFE into compliance with the NFIP.

Your property may be protected by an existing levee. A levee that protects your property may be owned by your local or State government or a Federal agency such as the USACE.

For more information about levees in your area, you can:

- Check your current FIRM to see if a levee or floodwall is already shown on the map as providing protection against the 1-percent annual chance (100-year) flood (see Section 2.6.2 for information about obtaining FIRMs)
- Call your local officials to request information about levees in your area (see Appendix D for your State NFIP coordinator)
- Check with your USACE office about any federally owned levees in your area (contact information is available at http://www.usace.army.mil/ContactUs/Pages/PageWithZones.aspx)
- Check FEMA's website at http://www.fema.gov/plan/prevent/fhm/lv_intro.shtm to learn more about levees

7.4.2 Considerations

Levee or Floodwall Height

The height of your levee or floodwall will be determined partly by the DFE you have chosen. However (as explained in Chapter 3), height limitations imposed by design complexity, construction cost, and property space requirements, coupled with the need to provide at least 1 foot of freeboard, usually restrict the use of residential levees and floodwalls to areas where flood depths are no greater than 5 feet and 3 feet, respectively. If the flood depths at your home are greater, you should consider an alternative retrofitting method, such as elevation (Chapter 5), relocation (Section 7.2), or demolition (Section 7.5).

WARNING

Your community's floodplain management ordinance or law may prohibit the construction of levees and floodwalls in the regulatory floodplain and floodway. If you are unsure about your community's requirements or the location of your property in relation to the floodplain and floodway, check with your local officials. See Section 2.6.2 for information about the floodway.

Remember that no matter what the height of a levee or floodwall, it can always be overtopped by a flood higher than expected. Overtopping allows water into the protected area, and the resulting damage to your home will probably be just as great as if it were not protected at all.

Safety and Security

Overtopping is a bigger problem for a levee than a floodwall. Even a small amount of overtopping can erode the top of a levee and cause the levee to fail. When this occurs, large amounts of water may be released at once and cause even greater damage to your home. When floodwaters threaten to overtop a levee, you may be able to raise the top of the levee temporarily with sandbags, but increasing the height of a levee increases the pressure of floodwaters on it and may cause the levee to fail.

WARNING

Because levees and floodwalls can push water onto other properties, you may find that local zoning regulations prohibit or restrict their use. Special permits may be required.

An important consideration for both levees and floodwalls is that they can give the homeowner a false sense of security. Every flood is different, and one that exceeds the height of your levee or floodwall can happen at any time. For this reason, you must not occupy your home during a flood.

Effect on Other Properties

A particularly important design consideration is the effect that a levee or floodwall can have on other properties. These barriers can divert floodwaters away from your home and onto other properties. They can also impede or block flood flows. As a result, they can cause water to back up into previously flood-free areas or prevent natural surface drainage from other properties.

Levee and Floodwall Size

Levees are earthen structures that rely on their mass to resist the pressures of floodwaters. To provide structural stability and resist erosion and scour, the sides of a levee are sloped – the width of the levee at its base is usually 6 to 8 times its height (see Figure 7-14a). As a result, the taller a levee is, the more space it requires. Most floodwalls do not rely solely on their mass for resistance to flood pressures. Therefore a floodwall will require less space than a levee of the same height, as shown in Figure 7-14b.

Soils

Most types of soils may be suitable for constructing residential levees. The exceptions are very wet, fine-grained, or highly organic soils. These soils are usually highly **permeable**. The best soils are those that have a high clay content, which makes them highly **impervious**. Using impervious soils for the levee and its foundation minimizes the seepage of water through or under the levee. Excessive seepage can weaken the levee and cause it to fail. If a sufficient amount of

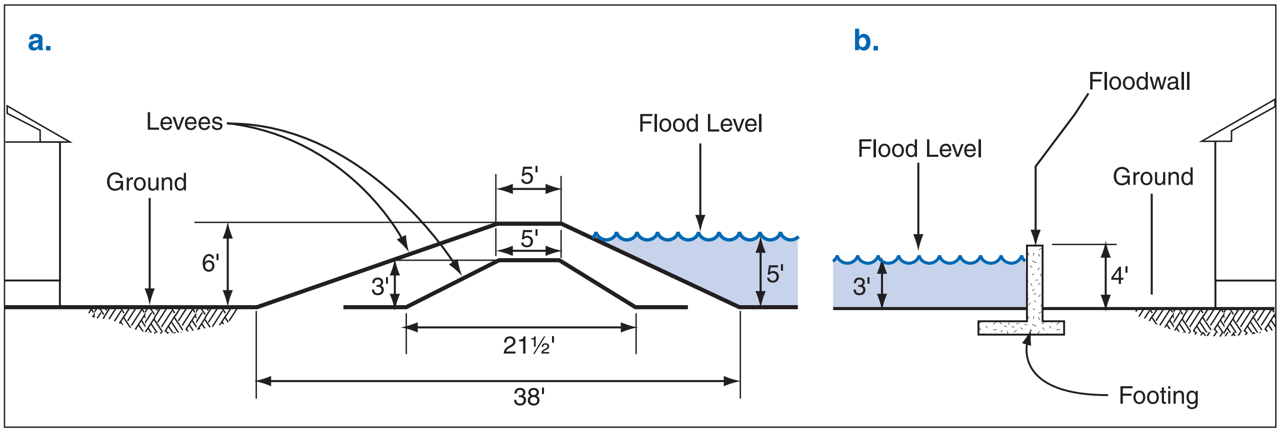


Figure 7-14. Cross-sections of a typical 3-foot high levee, 6-foot high levee, and 4-foot high floodwall. A 4-foot high floodwall (b) requires much less property space than a 3-foot high levee (a).

adequate soil is not available at the site of your home, the soil will have to be brought to the site or the levee design will become more complex. In either situation, the levee will be more expensive to build.

Soil type is an important consideration in floodwall construction as well. The soil under the floodwall, like that under a levee, must resist seepage. If the soils under a floodwall become saturated, the floodwall will no longer be adequately supported. As a result, the pressure of floodwaters can cause it to lean or overturn.

DEFINITION

Permeable soils are those that water can easily penetrate and flow through. **Impervious soils** are the opposite. They resist penetration by water.

NOTE

You can usually get information about soil types from local officials, the agricultural extension services of State universities, and regional offices of the NRCS of the USDA.

Hydrostatic Pressure

Levees and floodwalls are designed to resist flood forces, but they may not be able to protect a home from hydrostatic pressure. The migration of moisture through the ground below a levee or floodwall, as a result of seepage or the natural capillary action of the soil, can cause the soil in the protected area to become saturated (Figure 7-15). If this saturated soil is in contact with the foundation of the home, the resulting hydrostatic pressure can buckle slab floors, push homes up, and cause basement walls to bulge inward or collapse. If you plan to protect your home with a levee or floodwall, especially if you have a basement, your design professional should determine the potential hazard from hydrostatic pressure and take whatever steps may be necessary to protect against it.

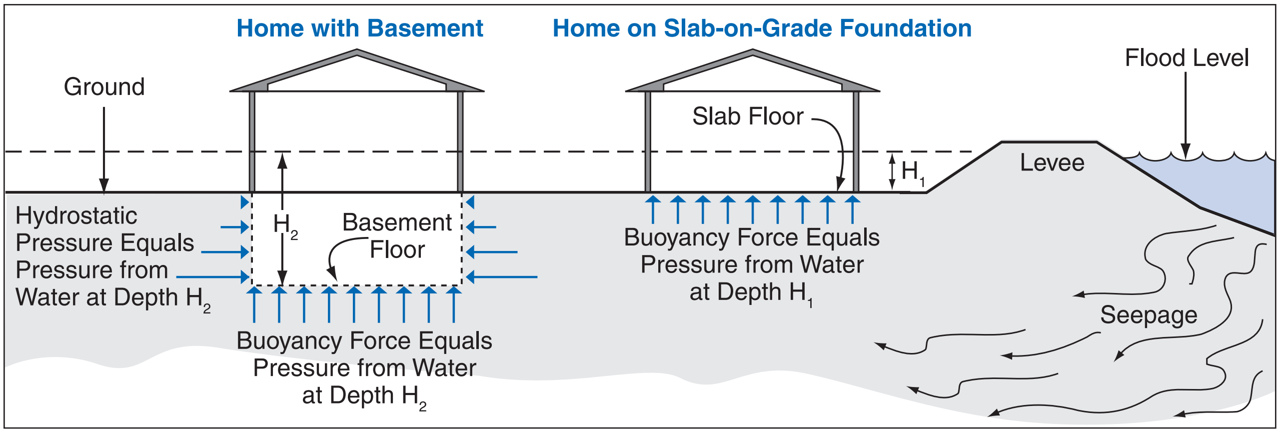


Figure 7-15. Hydrostatic pressure in saturated soils poses a threat to homes behind levees, especially homes with basements. The amount of pressure depends largely on the level of the home in relation to the level of the water on the flooded side of the levee. The higher the water level is above the lowest floor of the home (as shown here by depths H_1 and H_2), the greater the pressure.

Methods of reducing the risk of damage from hydrostatic pressure include moving the floodwall or levee farther away from the home, installing a foundation drain system (drains and sump pump), and filling in basements with dirt.

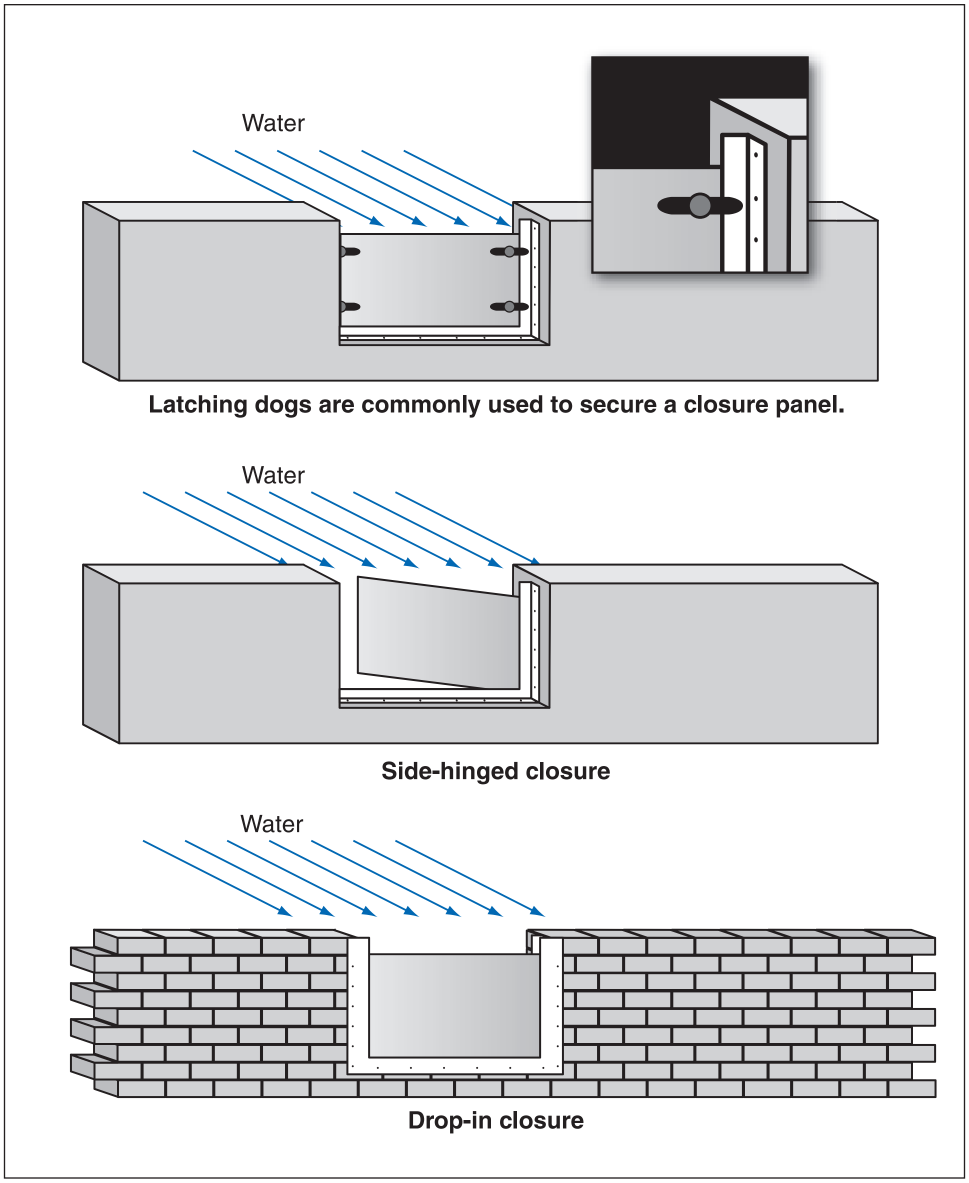
Flood Conditions

Levees are most effective against floods that have low flow velocities and durations of no more than 3 to 4 days. High-velocity flows can erode or scour the sides of a levee and possibly cause it to collapse. Levees can be protected from erosion and scour in several ways. The sides of all levees should be stabilized with grass, which helps hold the soil in place. The sides of levees that will be subjected to higher-velocity flows can be armored with concrete or broken rock. Aligning a levee so that it is parallel to the flow of water will also help protect it from erosion and scour, and reducing the angle of the side slopes will make the sides more resistant to scour. Where the duration of flooding is expected to exceed 3 to 4 days, a levee may not be the most appropriate retrofitting measure. When levees are exposed to floodwaters for prolonged periods, seepage and the problems associated with it are more likely to occur.

Access and Closures

Levees and floodwalls can block access to your home. If you build a levee or floodwall, you will usually need to provide openings or other means of access for driveways, sidewalks, and other entrances, but any opening in a floodwall or levee must be closed when flooding threatens. A variety of closure mechanisms are available. For floodwalls these include shields similar to those used in dry floodproofing (as described in Section 7.3.2) that are hinged to the wall or designed to slide into place. Prefabricated panels stored elsewhere when not in use are also acceptable (Figure 7-16). Acceptable closures for levees include permanently mounted, hinged, or sliding flood gates and prefabricated stop logs or panels.

Figure 7-16. Closure panels for floodwalls.



An alternative to incorporating openings is to provide a means of crossing over the top of a levee or floodwall. If a levee is low enough, a ramp can be created with additional fill material. Similarly, a stairway can be built over a low floodwall, as shown in Figure 7-17.

Interior Drainage

Building a levee or floodwall around a home keeps floodwater out of the protected area, but it can also keep water in – water that collects from rain or snow and from seepage during floods or, in the worst case, water that overtops the levee or floodwall. Two methods of removing this water should be used for all levees and floodwalls: drains and sump pumps. Drains installed at the base of a levee or floodwall allow collected water to flow out of the protected area. The outlets of the drains must be equipped with flap valves that close automatically during flooding to prevent floodwater from backing up through the drains into the protected area.

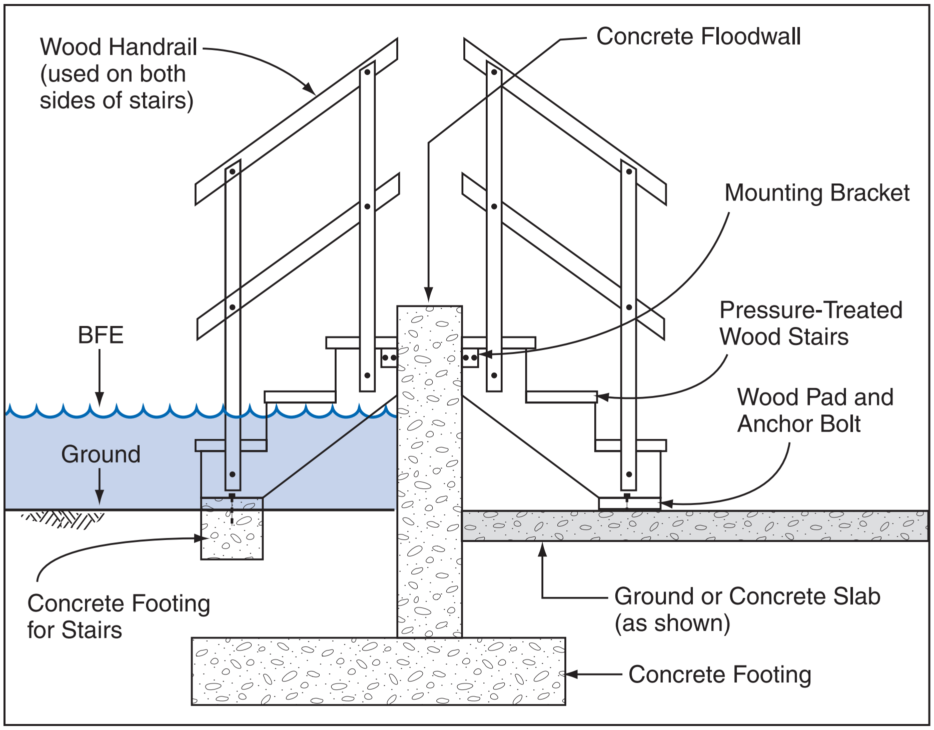


Figure 7-17. An access staircase over a low floodwall.

An electric sump pump should be installed at the lowest point inside the protected area. The pump must have an adequate capacity – it must be able to remove water from the protected area faster than water enters. An emergency power source, such as a gasoline-powered generator, should be provided so that the pump will continue to operate during interruptions in electrical service, a common event during a flood. Whenever possible, the downspouts from the roof of the home should be directed over the levee or floodwall so that they will not contribute to the collection of water in the protected area.

Inspection and Maintenance

After a levee or floodwall is constructed, you must inspect it periodically and make whatever repairs are necessary. Otherwise, small problems (e.g., settlement, cracking, loss of vegetation, and minor amounts of erosion and scour) can quickly become major problems during a flood. At a minimum, you should perform these inspections each spring and fall, before each impending flood if you have adequate warning, and after each flood. In addition, closure mechanisms should be inspected to ensure shields are accessible and gaskets have not deteriorated.

Protecting Service Equipment

Protecting a home with a levee or floodwall also protects any service equipment inside the home. When levees and floodwalls protect not only the home but an area around it as well, service equipment mounted on exterior walls, such as an electric meter, and equipment installed near the home, such as an air conditioning compressor, will be protected. But any equipment outside the protected area must be relocated, elevated, or anchored. Chapter 8 discusses the protection of service equipment.

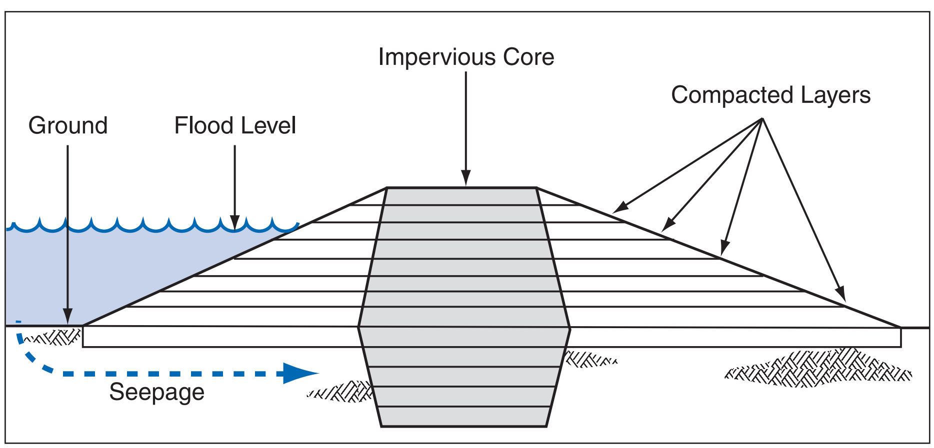
7.4.3 Levee Construction

The design professional must conduct an analysis of the soil at the site to determine whether it is adequate for use in the levee and to anticipate any foundation and seepage problems. When you construct a levee, you should try to take advantage of the natural terrain around your home. Depending on the topography of your lot, the levee may not have to completely encircle your home. You may be able to build the levee on lower ground and tie the ends into higher ground. An advantage of this technique is that the levee can often be made to look like part of the natural topography of your lot.

In preparation for construction, all ground vegetation and topsoil should be removed from the levee site. Sod should be set aside so that it can be used on the surface of the levee after construction. The levee should be built up in 6-inch layers, each of which must be compacted.

If there is a shortage of impervious soils in the area, the levee can be built with an impervious core and the available permeable soils can be used for the outer part of the levee, as shown in Figure 7-18. The core can be made of impervious soils or another type of water-resistant barrier. Above ground, the impervious core should extend the full height of the levee and be at least as wide as the width of the levee at the top. Below ground, the impervious core should extend at least 4 feet below the base of the levee and be at least 2 feet wide, The core will minimize seepage through the levee; however, the use of permeable soils on the outside of the levee will require that the angle of the side slopes be reduced so that erosion and scour are minimized. This is an important consideration when property space is limited, because reducing the angle of the side slopes will increase the width of the levee base.

Figure 7-18. Levees are constructed with compacted layers of soil. When an adequate amount of impervious soil is not available, the levee can be constructed of permeable outer soils and an impervious core.



If the soil underlying the levee is highly permeable, an impervious barrier may have to be constructed below the levee to control foundation seepage. Several types of barrier designs are available, but they are normally used for major levee projects and would usually be too expensive for a homeowner. The analysis of the soil at the site will reveal such problems.

As noted earlier, the height of the levee will depend on the DFE and the need for at least 1 foot of freeboard. Also, the levee should be built at least 5 percent higher than the desired elevation. This additional height will compensate for settlement of the soil that occurs naturally after construction.

7.4.4 Floodwall Construction

The design professional must perform a soils analysis similar to that performed for levee construction. The purpose is to determine whether the soils will support the floodwall and whether seepage or migration or water through the soil will be a problem.

Construction, which begins with excavation for the foundation, varies according to the type of wall. The two main types of floodwalls are gravity walls and cantilever walls (Figure 7-19). Both types resist overturning, which is the most common cause of floodwall failure, and displacement, but they do so in different ways.

The gravity floodwall relies on its weight and mass, particularly the mass at its base, for stability. The sheer weight of the materials used in its construction (usually solid concrete, alone or in combination with masonry) make it too heavy to be overturned or displaced by flood forces. Gravity floodwalls are relatively easy to design and construct. However, the size of the wall increases significantly with height so, as flood depths increase, a cantilever floodwall becomes more practical.

NOTE

A reinforced cast-in-place wall with a foundation at the proper depth provides an excellent barrier to seepage because it is constructed of a single, solid, water-resistant material. The reinforcement not only gives the wall strength to resist the pressure of floodwaters, but helps it resist cracking.

WARNING

Occasionally, floodwalls are built with a core of concrete block and a facing of brick. Even though the blocks are grouted, reinforced, and filled with concrete, experience has shown that this type of wall is neither as strong nor as resistant to leakage as cast-in-place concrete walls.

A cantilever floodwall consists of a wall and footing constructed of cast-in-place concrete (similar to a foundation wall and footing for a home). The cantilever floodwall relies partly on the weight of the floodwater and soil for stability. As shown in Figure 7-19, the "heel" of the wall (the portion of the footing on the flooded side) extends farther than the "toe" (the portion of the footing on the protected side). Through leverage, the pressure of water and soil on the heel helps counteract the overturning force of the floodwater. Reinforcement of a cantilever wall consists of steel bars embedded in the concrete.

Both masonry and cast-in-place cantilevered floodwalls can be faced with brick or stone or receive other decorative treatments that match or complement the exterior walls of a home (Figure 7-20). If your floodwall is connected to your home, as shown in Figure 7-20, it is critical to ensure that the connection between the floodwall and the home is tightly sealed.

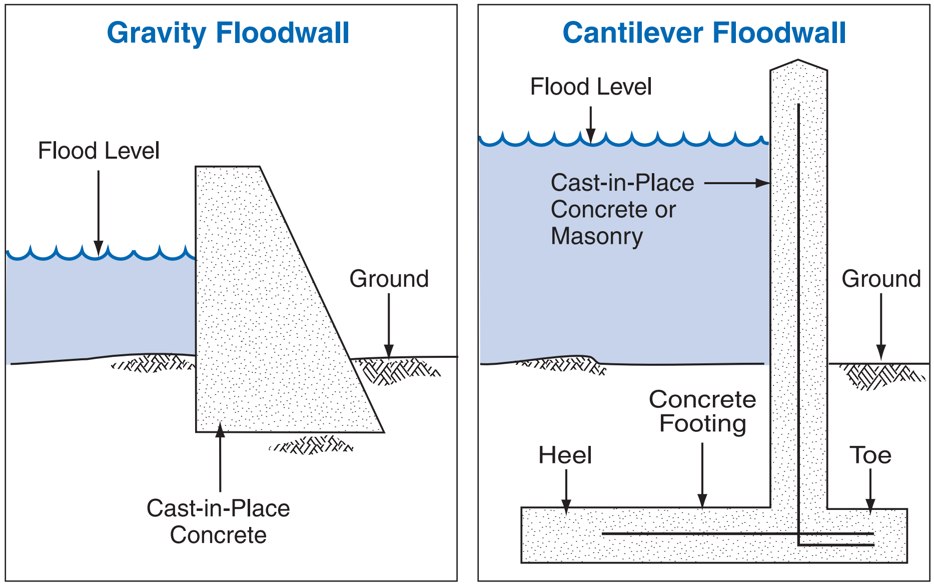


Figure 7-19. Gravity and cantilever floodwalls.

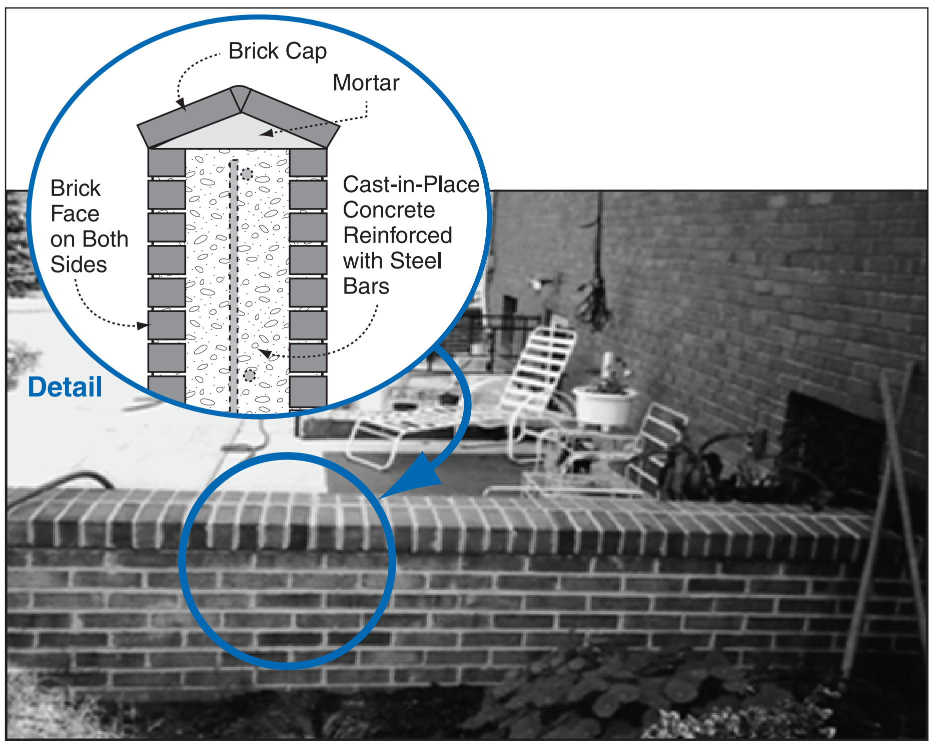


Figure 7-20. Typical brick-faced concrete floodwall. Detail shows cross-section through wall.

7.4.5 Temporary Flood Barriers

Temporary flood barriers use the same principles as permanent barriers such as floodwalls or levees, but can be removed, stored, and reused in future flood events. Historically, temporary barriers such as sandbags have been commonly used to fill openings or reinforce existing permanent barriers. However, in recent years, many newer temporary flood barrier products and systems have been developed to take the place of sandbag floodwalls and may also be used to reinforce existing permanent barriers or even create a new barrier. These new products include water-filled barriers or metal floodwalls designed so that they can be quickly installed and used numerous times.

In 2002, the Association of State Floodplain Managers (ASFPM) began working with the U. S. Army Corps of Engineers' National Nonstructural Flood Proofing Committee (NFPC) and other stakeholders to establish a national testing and certification program for temporary flood barriers. Over time, FM Approvals (a division of FM Global Insurance) developed an approval system for recognizing temporary barriers as flood abatement equipment for their insured customers. In 2006, FM Approvals distributed FM Approval Standard 2510, *Flood Abatement Equipment* (http://www.fmglobal.com/assets/pdf/fmapprovals/2510.pdf), which provides approval requirements for temporary flood barriers that protect against riverine flooding to a depth of 3 feet.

7.5 Demolition

7.5.1 Introduction

If a flood-prone home has been severely damaged, because of flooding or any other cause, demolition can be practical and effective. Demolition may also be practical for an undamaged home that, because of deterioration over time or for other reasons, is not worth retrofitting with any of the other methods described in this guide. If you choose demolition, you will tear down your damaged home and either rebuild a compliant home on the same property or move elsewhere, outside the floodplain. If you decide not to rebuild, your State or local government may buy or **acquire** your property. Depending on your choice of a site for your new home, this method can lower or even eliminate your flood insurance premiums. If you decide to rebuild, your **mitigation reconstruction** project may be eligible for FEMA grant money (see Section 2.7.1).

The demolition process involves disconnecting and capping utility lines at the damaged home, tearing the home down, removing debris and otherwise restoring the old site, and building or buying a new home. The most important

NOTE

Always use a licensed, bonded, and insured contractor for demolition projects and for reconstruction projects. Be sure that your contractor has experience with demolition (and construction for mitigation reconstruction) and understands the considerations discussed in Section 7.5.2.

DEFINITION

Acquisition is the process by which your State or local government purchases your flood-prone property, demolishes the building, and maintains the land as an open space.

Mitigation reconstruction is the construction of an improved, elevated building on the same site where an existing building and/or foundation has been demolished. Mitigation reconstruction is only permitted if traditional structure elevation cannot be implemented.

considerations involve how badly your home has been damaged and your options for building or buying a new home.

7.5.2 Considerations

Amount of Damage

Demolition is more practical for severely damaged homes than for those with little or no damage. If a flood, fire, earthquake, hurricane, or other disaster has caused extensive damage to the interior and exterior of your home or left it structurally unsound, you will probably find that tearing the home down and starting over is easier than making all of the necessary repairs. Also, remember that a severely damaged home in the regulatory floodplain will almost surely be considered substantially damaged under your community's floodplain management ordinance or law. Salvaging such a home would require not only repairing the damage but also elevating (including filling in a basement); wet floodproofing areas used only for parking, building access, or storage; or relocating the home as described in Section 7.2.

Rebuilding or Buying Another Home

Tearing down a home is the easy part of the demolition process. You must also buy or build another home elsewhere or rebuild somewhere on your existing property. Regardless of your decision, your goal is to greatly reduce or eliminate the potential for damage from floods, earthquakes, high winds, and other hazards. If you buy or build a home elsewhere, you'll want to find a site that is outside the regulatory floodplain, ideally one that is well above the BFE. You should also consider the other hazards mentioned above. Check with your local officials about this before you make your final decision.

When you buy or build a home elsewhere, you need to think about what you will do with your old property. Property that is entirely within the regulatory floodplain may be difficult to sell because of restrictions on its use. As explained in Section 2.7, some Federal programs provide grants to States and communities that they can use to buy flood-prone homes and properties. State and local programs may also provide financial assistance. Check with your local officials about this.

When buying or building a home elsewhere is too expensive, you may be able to rebuild on your existing property, either on the site of your old home or, preferably, on a portion of your property that is outside the regulatory floodplain. If you rebuild on the site of your old home, your community's floodplain management ordinance or law will require that the lowest floor be at or above the BFE. How you can meet this requirement depends on the flood zone and code requirements of your community. An important disadvantage of this approach is that you may not have access to your home during floods.

If your existing property includes a large enough area outside the regulatory floodplain, a better choice is to rebuild there. Building outside the floodplain gives you greater freedom to build the type of home you want. Also, because both the home and property are outside the floodplain, restricted access during flooding is less likely to be a problem.

Disruption of Occupants

Like relocation, demolition can be disruptive for the occupants of the home. Unless you decide to buy an existing home elsewhere, you must find a place to live and to store your furniture and belongings while your new home is being built.

Permitting

You or your design professional or contractor must check with local officials regarding permitting requirements for the necessary work. All permits for demolition should be obtained before the demolition process begins, including disconnecting and capping utilities, disposing of debris, new construction, and restoration of the old site.

7.5.3 The Demolition Process

Tearing Down the Old Home

Your utility companies must first turn off all services to the home. Your demolition contractor will then disconnect the utility lines. If you do not plan to rebuild on the same site, the contractor will cap the lines permanently or remove them according to the requirements of the utility companies. Before demolition begins, environmental hazards, such as asbestos, must be abated in accordance with Federal, State, and local requirements. Normally, a demolition contractor will bulldoze the home and then dispose of the resulting debris as required by Federal, State, and local regulations.

Restoring the Old Site – Acquisition

If you are not rebuilding on the old site, it must be restored according to the requirements of local regulations. Site restoration usually involves demolishing and removing not only the home, but also any pavement, such as a driveway or patio; grading to restore areas disturbed by the demolition; and stabilizing the site with grass.

If your old site included a septic tank or fuel storage tank, you may have to meet the requirements of environmental regulations aimed at preventing contamination of the groundwater. You may be required to drain and remove aboveground and underground storage tanks (ASTs and USTs), or you may have to anchor them to resist flotation. You may also be required to test the soil around an UST to determine whether leakage has occurred. As the homeowner, you will usually be responsible for cleaning contaminated soil if there has been any leakage from the tank. In this situation, you will need the services of a qualified geotechnical or environmental engineering firm.

Local utility companies or regulatory officials can inform you about requirements concerning capping, abandoning, or removing various utility system components.

Rebuilding – Mitigation Reconstruction

Your construction contractor will prepare the site and build your new home according to the local building code, floodplain management, and zoning requirements. Therefore, the lowest floor of your new home must be at or above the BFE, and you will not be allowed to build a home with a basement. Figure 7-21 shows a mitigation reconstruction project that was recently completed in Louisiana following Hurricane Katrina.

WARNING

If you rebuild on the site of your old home, your community's floodplain management ordinance or law will not allow you to have a basement below the BFE.

Depending on where you decide to rebuild, local utility companies may have to extend new lines into the site of your new home. Usually this is done before construction is completed. Your contractor will hook up the utility lines as part of construction. You may need the services of a design professional if specialized utility systems are required because of the location of your site, the type of home you decide to build, or the nature of the hazards at the site.

Figure 7-21. Typical mitigation reconstruction project.